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ABSTRACT

This report describes a comparison of two methods of instruction, traditional and hands-on science on students' achievement in science. The study included 40 students (most in ninth grade) at a rural high school in West Virginia. Findings indicate that hands-on instruction in science resulted in greater achievement than traditional instructional methods. (Contains 44 references.) (WRM)

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A Comparison of Traditional Science Instruction to Hands-On Science Instruction

A Thesis

Presented to

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of the Requirements for the Degree

Master of Arts in Education

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ABSTRACT

A Comparison of Traditional Science Instruction to Hands-On Science Instruction

The purpose of this research project was to determine if the students' academic achievement remained constant when two different methods of instruction were used. The methods of experimentation were traditional and hands-on science.

The research was acquired from forty science students enrolled in Coordinated and Thematic Science 9. The study was conducted over a twelve week period of time at a rural high school in West Virginia. The students covered material from three chapters in their science book using the traditional method of instruction. The same students then received hands-on instruction again covering three chapters, but these were not in the text. The students used various types of group work including cooperative learning.

Academic grades were averaged over the duration of the experiment. A comparison was made of the final average for each method of instruction. The hands-on instruction method had a 3% higher overall grade point average which was statistically significant.

Dependent samples were used in this research since two values were received from each student. The hypothesis test for a claim about two dependent populations was calculated. The statistical comparisons indicated a better academic grade for students receiving the teaching method of hands-on science.

Chapter 1

Introduction

Purpose of the Study

The purpose of this study was to compare traditional science instruction to the hands-on science approach. In the process of this comparison, a look at where science has been and where it is going was necessary. Hands-on science is the newer form of scientific inquiry. If science teachers are to use this method of instruction, they must decide if it is beneficial for students.

Several recommendations for improving traditional science instruction have already been made. This study examined both the positive and negative aspects of traditional science instruction and compared these findings to the results of the hands-on approach. New recommendations were for more hands-on science which has brought about the need for cooperative learning. Pros and cons of cooperative learning were revealed. Research has shown that the use of hands-on instruction in the classroom improves the comprehension ability of students. This was an improvement over the use of the traditional textbook approach. Students receiving hands-on instruction also showed improvement in their attitude toward science (Collison, 1993).

Science assessment was also important in this comparison. Hands-on science enhances students total ability in science. Studies show significant academic gains for students using hands-on science (Collison, 1993).

Research Question

Do science students learn better through traditional science instruction or hands-on science instruction?

Hypothesis

H_0: Science students learning by traditional science instruction will have the same academic achievement as students who learn by hands-on science instruction.

H_1: Science students learning by hands-on science instruction will have higher academic achievement than students who learn by traditional science instruction.

Limitations

This study included students from a rural high school in West Virginia. The population of the high school was approximately 600-625 students. The student population in this study was limited to 48 students from selected sections of Science 9. Most students were ninth graders, but a few were tenth, eleventh, and twelfth grade students. Special education students were also included in this selection of students. Even though these students were enrolled in Science 9, they are not all equal in ability levels. The time frame was also short in duration, lasting for a few weeks instead of months.

Assumptions

Various assumptions were present in this study:

1. Students were at various ability levels but are able to function in a ninth grade science class.
2. The teacher was capable of instruction in the traditional style and the hands-on style.
3. A sample of 48 students was an adequate size to do the experiment.
4. The time frame of 12 weeks was long enough.
5. The assessment tests will show correct results.

Definitions of Terms

1. Cognitive learning is our information processor, for memorization and our communication center (Johnston, 1996).

2. Inquiry-oriented science emphasizes student involvement, hands-on learning, and experiential or activity-based instruction (Haury, 1993).

3. Laboratory experience is often labeled hands-on, inquiry based, experiential, or cooperative learning (Collison, 1993).

4. The traditional teaching method is accomplished by means of the lecture, recitation, and is supplemented by audio-visual aids and the textbook (Collison, 1993).

5. Cooperative learning is a process designed to improve comprehension at a variety of grade levels through structuring positive interaction among students in a variety of small group patterns (DeLude et al., 1997).

Importance of Study

This study is important because it will attempt to show which method of science instruction will best help students learn. The traditional science approach has been used in years past. The hands-on science technique has been utilized by some teachers for the last several years. Some science studies have already claimed that students learn best by the hands-on science method, and school systems are requesting that teachers include more hands-on science. This study will show whether traditional or hands-on science is better for students.

Chapter 2

Literature Review

The purpose of this review was to determine which form of science instruction is better for students. In order to determine this, science history was briefly discussed and the need for change in science. Traditional science instruction was compared to hands on science instruction. Also science assessment was discussed to determine student achievement with regard to traditional versus hands-on. Should teachers change their science teaching methods completely?

History of Science

Science, like other subjects, developed from social institutions. Many modern ideas were organized by the changes caused through social movements. From the Athenian movement civilization gained a belief in the value of critical thinking, and from the Italian Renaissance mankind received the method of inductive reasoning. The inductive method involves reasoning logically and methodically. Christian influence placed emphasis on the present-day educational philosophy of desirable conduct, and the designing of all phases of educational scheme to provide for the best interests of the individual child. Modern schools do not limit themselves to the methods of classicists, but they go beyond (Hughes, 1970).

In the 1930's researchers began to take a more objective look at teaching effectiveness. This paralleled the beginnings of the child development movement. Early analysis of the effects of teaching showed a general lack of interest in the

research topic. A delay occurred in the development of objective, valid, and reliable methods of examining teaching styles and pupil learning (Silvernail, 1979).

After the successful launch of the Soviet satellite, Sputnik, in 1957, a growing concern about the ability of science teachers, especially elementary teachers, to teach science effectively escalated. The launch created criticisms of all grade levels and science disciplines in the United States (Dana et al., 1997).

In the 1960's, the National Science Foundation supported or funded projects to provide teacher institutes, science curriculum projects, and teacher education workshops. Programs influenced by the work of Robert Gagne, Jean Piaget, and Jerome Bruner were supported by the U.S. government and science education communities. The projects emphasized learning scientific inquiry processes, learning valid scientific concepts, and engaging students actively in exploration with materials. In the 1960's and 1970's; however, teachers faced the realities of limited school budgets, limited teacher knowledge of science, safety, problems of material management, and a lack of support from administrators and colleagues that brought about very little change in school practices (Dana et al., 1997).

By the late 1970's, science courses were basically the traditional textbook approach of rote learning. Approximately 90 percent of science teachers participated in this method. Science was viewed as specific content to be mastered and was not responsible for influencing interest in science. The textbook had become the course outline, the testing, and the view of science (McNeil, 1996).

Hands-on science developed slowly in America. It was developed from the Pestalozzian theory (Haury & Rillero, 1992). The Committee of Ten was important in securing a place for science in the school curriculum. The science committees stressed the importance of object manipulation by students. The Physics, Chemistry and Astronomy Committee recommended experiments carried

on by the pupil. Each curriculum group stressed the virtues of hands-on experiences to gain greater insights into the basic concepts of science. Hands-on learning comprises three dimensions: the inquiry dimension, the structure dimension, and the experimental dimension (Haury & Rillero, 1992).

In the early 1980's, national reports focused on declines in student achievement in science which brought about a renewed interest in science teaching. In the mid-1990's, more reform efforts resulted in the development and publication of education standards in science and other disciplines. The American Association for the Advancement of Science called for major changes in science curricula, methods of teaching, and the measures used to assess student mastery (Dana et al., 1997).

Traditional Science Instruction

Science has many definitions. Science is a kind of knowledge and a way of gaining and using that knowledge. According to Kuslan and Stone (1968), science by textbook tends to be only product and real science is both product and process. The scientific method, the philosophical foundation of most textbook discussions, appears with regularity in most science books.

In 1972, Renner and Stafford stated that one objective of secondary school science was to develop a command of rational powers. A second objective of secondary school science was to develop the students' ability and confidence to inquire. A third objective was to develop an understanding of the changing nature in the environment, and finally the fourth objective was to teach science using materials and content.

Three practices are commonly used to involve students in the study of science. One level consists of students reading about the processes and products

of science or simply being told. The second level of student involvement is discussion among the students or discussion between students and teacher. A third level of student involvement in science is teacher demonstrations of a science experiment or students demonstrations for each other (Renner & Stafford, 1972).

In order to understand what occurs in the classroom, it is necessary to remember that the teacher, the individual student, a group of students, or a mixture of any of these can be involved. Each has its own characteristics. The teacher's goal, according to Alcorn, Kinder, and Schunert (1970) is to promote behavioral changes in the cognitive, affective, and psychomotor realm of learning. The teacher's primary concern is how to deliver these objectives. The teacher brings a personality, attitude, social outlook, and many other factors to the classroom. Students bring even more factors, including their personality, attitudes, abilities, etc. When students as individuals become a class they have additional characteristics (Alcorn, Kinder, & Schunert, 1970).

PROS of Traditional Instruction

The textbook is firmly rooted in the schools of the United States. The textbook has influenced the past and is an influence now. The general public approves of textbook usage. Curriculum is based upon textbooks and the methods of teaching. There is a close relationship between the course of study and the text, and the systematic instruction according to topics in the textbook (Gwynn & Chase, 1969).

Some pros of the textbook as seen by Chase, Jr. and Gwynn are (a) many students come from underprivileged homes, and textbooks are their main resources; (b) the textbook becomes the factual source for the student; (c) the textbook is ranked in vocabulary; (d) the text illustrates and enriches teaching; and

(e) the text helps the teacher to improve his/her methods of teaching through various suggestions in its teaching manual (Gwynn & Chase, 1969).

At least five instructional methods that help students read scientific texts can be used (Digisi & Yore, 1992).

1. Providing activities with information that will help students organize what they are reading.
2. Helping students recall information more accurately.
3. Teaching students to create maps that show how the ideas in a text are related.
4. Teaching students to determine patterns in how a scientific text is written.
5. Asking students questions on concepts.

David Ausubel is an educational theorist. He believes that textbooks can be very useful tools in the classroom. Ausubel believes that subject matter should be learned, and he advocates the improvement of presentational methods. He has a theory on verbal learning that depends on: (a) how knowledge is organized, (b) how the mind processes new information, and (c) how teachers can apply these ideas about curriculum and learning. The teacher, Ausubel feels, plays the role of organizer of subject matter and presenter. The teacher presents information through lectures, readings, and also provides tasks that help the learner combine what has been learned. He believes that students need to be active constructors of knowledge (Allyn and Bacan, 1996).

David Ausubel uses two principles: progressive differentiation and integrative reconciliation. "Progressive differentiation means that the most general ideas of the discipline are presented first, followed by gradual increase in detail and specificity. Integrative reconciliation simply means that new ideas should be consciously related to previously learned content." (Joyce & Weil, 1996).

If the teacher directly controls instruction then this is called teacher-centered. Teacher-centered strategies include lectures, discussions, questioning, and demonstrations (Sealey, 1985).

Lectures can be very effective in the classroom. Lectures help teachers to introduce a topic, to provide multiple examples in a short time, to facilitate whole group instruction, and to summarize key points. Other reasons to lecture are to generate student thinking and questioning, to teach processes, to give directions, to provide organized perspective of important concepts, and establish a learning interest (Kuzbik, 1992).

Effective learning in the traditional classroom as proposed by Kuzbik can be divided into three types of lectures: interactive, mastery, and traditional. Interactive lecturing engages critical thinking during the lesson by processing new information. Mastery lecturing links new knowledge to familiar concepts and ideas. Traditional lecturing presents information while relying on the teacher's knowledge, humor, language, enthusiasm and organizational skills.

Kuzbik also agreed with David Ausubel that information can be organized, sequenced, and connected. These ideas come together to be called information organizers. Effective lecturing requires the teacher to present new information in the same way we learn. Teaching activities should make learning meaningful, make concepts clear, and allow students to critically examine new information. Information organizers are aids that can be used during a unit of study or with various instructional methods (Kuzbik, 1992).

Discussion is a traditional instruction method. According to Alcorn, Kinder, and Schunert (1970) a good discussion has purpose, is based on important information that shares ideas, draws in all students, has mutual respect for different opinions, and should lead to some conclusions.

Clark and Starr (1976) feel teachers who handle discussions well are also effective. Discussion promotes better thinking skills and clearer understanding. Everyone should participate in an effective discussion although it is not necessary for each student to talk. Students can participate differently. A successful discussion achieves its purpose and leads to some sort of conclusion.

Teachers, in order to aid student learning, give classroom support. Teachers place importance on providing learning goals, frequent reviews and feedback to students. Teachers help build relationships and harmony with students. Teachers encourage students to attend class, be prepared, stay on task, and follow directions (Warkentin, 1994).

CONS of Traditional Instruction

The methods used to teach science determines whether the program is successful or unsuccessful. Science can be taught as a subject to be taken on trust alone or a subject to be questioned. How the teacher approaches the subject depends on the teachers understanding of science and their belief about how students learn (Otto, 1995).

Teachers who restrict their science teaching to a textbook impel a passive role for their students. These teachers are asking students to memorize science content, but they often later find that these students cannot transfer that information from one situation to another (Otto, 1995).

Many reasons are given why some teachers oppose the use of a textbook or the use of a single textbook. The main reasons, according to Gwynn & Chase, (1969) are:

1. Textbooks are outdated when they come off the press.
2. The illustrations are outdated.
3. One text cannot give a true representation of scientific growth.

4. The authors disagree on aims to be achieved and presentational methods.

5. The author is slow to add national recommendations to the textbook.

6. The textbook becomes what the teacher is supposed to know and what the students must learn.

7. The textbook handles controversial issues and topics poorly.

Most American schools offer traditional instruction in science. Relatively few schools are changing their curriculum for a hands-on approach. Teachers are uncertain, uncomfortable, and many have limited backgrounds with experimental approaches to teaching science. Some are too dependent on textbooks or are reluctant to engage in manipulative learning (Haury & Rillero, 1992).

Hands-on Science Instruction

Science curriculum needs to promote active learning, inquiry, problem solving, cooperative learning, and other instructional methods. Students need to be motivated (Haury, 1993). Inquiry-based programs have usually been found to improve student performance, especially laboratory skills, graphing skills and interpreting data (Mattheis & Nakayama, 1988).

The teacher becomes a teacher-manager when he/she creates a learning environment in the classroom with predefined objectives. The teacher must plan, organize, lead, and control (Davies, 1973).

Hands-on science can include a variety of activities such as actually conducting an experiment, participating in a scavenger hunt, watching a video, reading journals, going to a museum, using a computer, and completing a science

project. Students can grow in their ability to learn and actually develop the will to learn (Johnston, 1996).

In 1994 LeBuffe emphasized seven reasons for hands-on science:

1. Hands-on science is fun.
2. Hands-on science is instructionally sound.
3. Hands-on science provides the occasion for interdisciplinary learning.
4. Hands-on science promotes curriculum alignment.
5. Hands-on science accents activities in the real world.
6. Hands-on science can increase parent involvement.
7. Hands-on science is excellent for the use of cooperative learning

(Johnston, 1996).

Cooperative Learning

"Cooperative learning is a process for learning any content at a variety of grade levels by structuring positive interaction among students in a variety of small group patterns" (Delude et al., 1997, p. 39). Cooperative learning groups usually have two to five students working together to reach a common goal. This allows the students to help each other while the teacher is free to monitor learning and peer teaching (Jones, 1987).

PROS of Cooperative Learning

Studies show that cooperative learning can improve many areas such as friendships, self-esteem, attitudes, and better racial relationships. Cooperative behavior skills also encourage politeness, loyalty, and positive peer relationships. Improvements are seen in the acceptance of mainstreamed students and in the students' ability to function as a group. Finally, teaching children at school to

cooperate can carry over to home, play, and eventually work (DeLude et al., 1997).

In a recent study of cooperative learning, Kreke and Towns (1997) found that (a) cooperative learning created an environment that encouraged challenge, support, and trust, (b) students developed interpersonal skills and communication skills, and (c) cooperative activities gave students the tools for learning the material.

Collison (1993) did a study on science teachers' attitudes toward the use of hands-on instruction in their science classes. He found that all teachers supported the use of hands-on science instruction and felt that hands-on teaching improved a student's ability to comprehend science when compared to using the textbook only.

Many lab and field research studies show that cooperative learning has produced other positive outcomes. Three important ones are (a) academic gains, (b) better race-relations in integrated classrooms, and (c) improved social development among students (Kagan, 1994).

Cooperative learning encourages higher achievement than that of individualistic learning structures. Slavin (1983) analyzed controlled research studies which showed superior outcomes for cooperative learning. From the studies examined, 63% showed superior outcomes for cooperative learning, 33% showed no differences, and 4% showed higher achievement for the traditional comparison groups.

Cooperative learning has improved ethnic relations among students. Research done by Kagan (1994) demonstrated great improvements in ethnic relations. Overall, cross-ethnic friendships improved more than in the control classes.

The ability to work and to communicate with others has greatly improved in the cooperative learning classroom. Cooperative learning becomes a part of

curriculum reform in order to prepare our students for a job. Students become better able to solve problems, switch roles, and become more cooperative with others.

CONS of Cooperative Learning

Obviously cooperative learning depends on good discipline management. In some classrooms, teachers are afraid of peer involvement because of the possibility of the whole class getting out of control (Jones, 1987). Some lab activities only follow a cook-book style of manipulative skills. This does not develop many cognitive skills. Also science process skills such as identifying problems are left out (Shimizu, 1997). Clark and Starr (1976) gave reasons for group failure such as inadequate preparation of the group by the teacher, lack of a goal, and in sufficiently defined student roles. Sometimes the failures are caused by groups in which the students do not get along. The students have just not learned to work together, and the lack of student motivation can make any approach fail.

Many science teachers do not have available the equipment to conduct hands-on science activities. The most frequently mentioned needs were running water, electrical outlets, gas, hoods for labs, videodiscs, and CD-ROM players (Weiss, 1993). A few other needs for cooperative learning are resources to develop hands-on activities, storage for materials and equipment, and teacher training and experience (Haury & Rillero, 1992).

Science Assessment

Assessment must be more closely aligned with the goals of science instruction. By using more assessments such as performance-based, the portfolio,

or multiple choice tests that require thought beyond simple recall, more higher order thinking skills can be assessed. Students must have different ways for communicating what they know and understand. The opportunity to demonstrate ideas, to develop quality results, and to make oral, visual, or written presentations are needed (Sivertsen, 1993).

Two main reasons for testing students are to make the teacher accountable for learning and to sum up the effectiveness of the learning activities that students experience. The teacher also uses assessment to let the students and parents know how the students' work measures up. The instructor needs to know whether students are catching on to certain concepts and procedures. Testing helps the teacher evaluate the instruction program (Brown & Shavelson, 1996).

According to Smith (1993) there are three characteristics of science assessment:

1. Investigate students' knowledge base, reasoning, understandings, and problem solving skills.

2. Include hands-on performance tasks in which student students show thinking and laboratory skills.

3. Align assessment with curriculum and instructional reform.

Science education has a need to develop assessments that measure scientific reasoning skills and competence in applying techniques. These efforts usually involve the use of hands-on performance exercises. Hamilton in 1994 identified six broad categories of cognitive demands that tasks place on students:

1. Demands on working memory (that may be too advanced for the student).

2. Language requirements may prevent some students from showing important scientific capabilities.

3. Metacognitive skills-students being able to be successful problem solvers.
4. Application of prior knowledge and expectations.
5. Being able to assimilate new information.
6. Being able to apply scientific processes to new problems.

Characteristics of performance-based assessment in science are that (a) the task requires student involvement to solve, (b) students produce the solution, and (c) students construct and communicate responses. Performance assessments in science can be based on a variety of methods:

1. Performance tests/tasks. These are hands-on activities in the science classroom in which students do the lab work.
2. Open-ended questions. These questions allow students to reveal their understanding of a topic in their own words.
3. Student journals. These are writing techniques that may be used as a dialogue between student and teacher about scientific concerns.
4. Computer simulations. These simulations can monitor students' knowledge and abilities in science.
5. Portfolios. This is a collection of student work that documents the student's learning in the science classroom.
6. Concept maps. This is a method for students to recognize the concepts of a particular topic and to connect them in a meaningful way.

Performance assessments allow valid assessments of attitudes and dispositions about science. This is different from pencil-and-paper multiple choice tests. Also, performance tasks allow teachers to observe and assess students in performing science process skills. These skills include observing, classifying, inferring, measuring, predicting, and experimenting. This provides the opportunity for all

students to perform by having a variety of approaches and responses to the tasks (Smith, 1993).

Performance assessment tests do have some problems that teachers need to be solve. From talking with teachers, some have problems in dealing with handling materials, maintaining clutter control, and dealing with classroom management for testing. Other teachers feel uncomfortable judging whether performance assessments are doable or not in their classroom. Cost is another factor in buying various materials and supplies to make up testing kits. Another consideration is the amount of class time it takes to test students. Many teachers are reluctant to spend more than one class period for testing. Another problem is the time the teacher needs to spend scoring a performance assessment test (Brown & Shavelson, 1996).

According to the National Science Education Standards (1996) there are five areas from which to judge the quality of assessment practices:

1. The consistency of assessments.
2. The assessment of both accomplishment and opportunity to learn science.
3. The balance between the technical quality of data collected and the outcome of the actions taken on the basis of the data.
4. The fairness of testing practices.
5. The soundness of conclusions made from assessments about student achievement and opportunity to learn.

Reform In Science Education

In 1971 Williams and Herman, Jr. compared science objectives. One of the purposes of science was to increase a child's curiosity. Later this changed to

instruction. Most teachers believe science instruction should provide some concrete experiences, and students learn best when they study science in social applications. Most teachers also support the use of cooperative learning in the science classroom (Weiss, 1993).

Some resistance is met by teachers. Most disagree with teaching science concepts before teaching terminology of those concepts. Many teachers still emphasize learning factual information in science. Many teachers doubt heterogeneous grouping is the way to secure success for all students, and most science teachers are pleased with the quality of their science textbook (Weiss, 1993).

A group of Michigan school districts worked to improve student improvement, increase teachers' abilities, and to improve their science education programs. Some of the areas they worked to improve were (a) professional development, (b) strong leadership, (c) support and sharing of ideas, (d) technical assistance, (e) better policies, and (f) a sense of partnership with everyone involved including communities (Parsons & Jessup, 1996).

The West Virginia Department of Education and the W.V. Board of Education are committed to the improvement of science education. Some of the conditions creating a demand for change in science education are (a) changes in world society, (b) international competitiveness, (c) changes in the role of technology, (d) changes in the sciences, and (e) research and learning about actual instruction. The transforming of science education in West Virginia began with the adoption of a new curriculum framework in 1993. The program offers K-10 with a thematic, coordinated approach to the study of science (W.V. Science Curriculum Framework, 1994).

Teachers envision a learning environment in which the student is valued and is considered in all phases of educational planning. Our mission as teachers is to engage, nurture, and respect our students. Teaches must provide knowledge and skills and communication. Teachers must provide opportunities for problem solving and provide weekly occasions to experiment within and beyond the classroom (Johnston, 1996).

Project 2061 of American Association for the Advancement of Science has pushed to reform K-12 education. The science curriculum will expect students to explore concepts more in depth. Vocabulary and memorization procedures will become less. Boundaries between traditional subject matter categories will be broken down. Topics usually not found in school such as scientific enterprise will be addressed (Willis, 1995).

The challenges are important not just for project 2061 or science education, but for all reform efforts. The project is also working with teachers, teacher educators, and material developers to analyze curriculum materials for their match to specific learning goals. For such reform to happen, educators will need a great deal of help and support (Roseman, 1997).

Chapter 3

Method

Subjects

Forty students were involved in this study of traditional science compared to hands-on science instruction. The students were randomly selected by the computer when they registered for Coordinated and Thematic Science 9. Of the forty students, thirty-four were ninth graders, and six of the students were either tenth or eleventh graders repeating Science 9. The students ranged in age from fourteen to seventeen years old. The students were a mixture of nineteen boys and twenty-one girls with a variety of ability levels. No students were dropped from the study.

Procedures

The data for this research were collected from two sections of CATS 9. A total of forty students were involved over a period of twelve weeks. The forty students were both the control and experiment group. The students were taught science using the traditional science instruction for six weeks. This was considered the control group. Next they were taught science using hands-on instruction for six weeks. This was considered the experimental group. The students' academic grades were compared after each six weeks period to see if there was a difference in academic achievement. The same instructor taught all the students so as to eliminate confounding variables.

Control Group

No specific instructions were given to the groups. The students acted as the control group when they received traditional science instruction for a six week period. Three chapters were covered in the course of this time period. The three chapter topics were as follows: Electromagnetic Waves, Periodic Table, and Molecules in Motion. Each chapter was covered in the traditional instruction method. The teacher used traditional instruction such as lecture, overhead transparencies, and demonstrations. Students were told to read the pages in the book and were told to answer the questions at the end of each section. A worksheet was also completed for each section. At the end of each chapter the students completed a set of chapter review questions. A study guide was provided to all students to help them study for their test. The test was commercially prepared by the textbook company. Grades were then averaged.

Experimental Group

The students acted as the experimental group when they received hands-on science instruction for a six week period. Three science topics were covered in the course of this time period. The three science topics were as follows: Metric system, Density, and the Microscope. Each topic was covered using hands-on science instruction, and no textbook was used. The teacher used some lecture to explain the basics or to cover instructions. The students used various labs (experiments) to learn the science material. The students worked in lab groups of three or four students. Sometimes the students worked in regular groups and sometimes in cooperative learning groups. Their lab papers were done as individual grades (each student was responsible for doing his or her own

paperwork), and sometimes one lab paper was turned in for the whole group's grade (cooperative learning). Students received handouts and with some labs they did a worksheet. A study guide was provided to all students to help them study for their test. The tests were prepared by the teacher following the basic form of commercially prepared tests.

Design

The design of this experiment was a quasi-experiment. The students were from intact groups chosen by the computer. A comparison was done of the relative effectiveness of two different methods of instruction (Crowl, 1996).

This experiment is an example of a dependent t-test. If one sample is related to the other, then the samples are dependent. The dependent samples have two values from each person (Triola, 1995). A dependent t-test is used for comparison of grade point averages as was done in this experiment.

Design 5, Posttest-Only Control Group, is used in this experiment. The design avoids problems associated with pretesting by not using a pretest (Crowl, 1996).

	Random Assignment	Treatment	Posttest
Experimental Group	R	X	0
Control Group	R		0

Instrumentation

Commercial tests used were:

1. Electromagnetic Waves
2. The Periodic Table

3. Molecules in Motion

The chapter tests contained objective questions that test facts and numerous short answer questions. Also a few essay questions are used to require students to apply and relate concepts (Aldridge & others, 1993).

The textbook, Science Instructions 3, which was used, was on the state approved adoption list. The textbook and its components met state basic guidelines for state objectives and goals.

Self-made teacher tests were:

1. Metric System Test
2. Density Test
3. Microscope Test

The hands-on science tests contained objective questions that test facts and numerous short answer questions. Some questions were based on lab procedures or happenings with limited use of essay questions. These tests were made to be similar in composition to the commercially made tests. The self-made teacher tests were valid in that they were based on state objectives and goals for CATS 9. The commercially made tests were found to have no validity available. Glencoe Science textbooks and materials were approved for adoption by the State Science Adoption Committee.

Chapter 4

Results

Sample

The research was conducted using forty students enrolled in Coordinated and Thematic Science 9. Most of the students were from low and middle income families. The students were randomly selected by the computer when they registered for Science 9. The students selected were from two different class periods. One class period contained nineteen students while the other class period contained twenty-one students. Thirty-four of the students were ninth graders, three students were tenth graders, and three students were eleventh graders. The tenth and eleventh graders were repeating Science 9. The students were a mixture of boys and girls with a variety of ability levels.

Findings

Analysis of the data collected during this experiment showed that using hands-on science in the classroom significantly improved the academic grades of students. The comparison of academic grades for the traditional group and the hands-on group during a twelve week period indicated improvement.

Results

The two basic areas compared during this experiment were:

1. Traditional science academic grades
2. Hands-on science academic grades

A comparison of the academic grades of the two science groups found an improvement of 3%. The traditional group had an overall average grade of 80%, and the hands-on group had an overall average of 83% as shown in Table 1.

Table 1

Average	Traditional	Hands-on
Academic Grade Comparison	80%	83%

The average academic grades were compiled by averaging three chapters. For traditional science, chapters 4, 6, and 8 were compiled. (Chapter 4 - Electromagnetic Waves; Chapter 6 - The Periodic Table; Chapter 8 - Molecules in Motion). The hands-on science chapters were also compiled by averaging. The chapters were on the Metric System, Density, and the Microscope. The 3% improvement in the students' grades was enough to be significant.

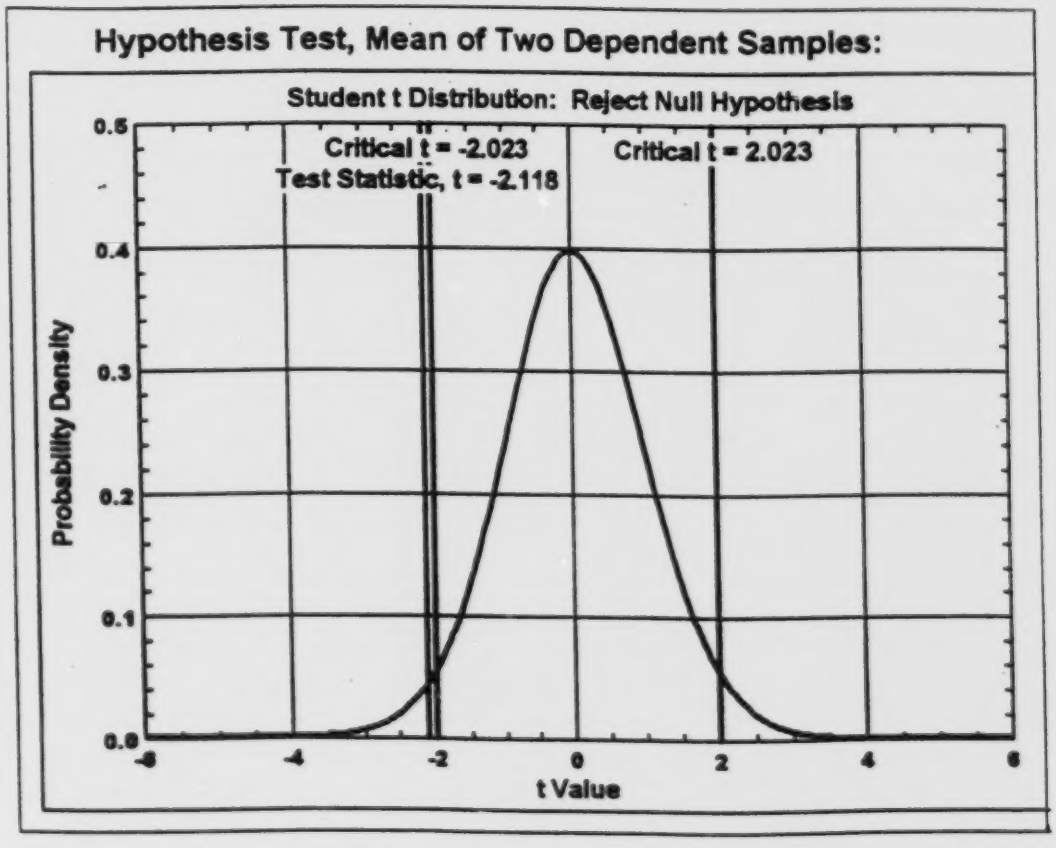
Control Group vs. Experimental Group

Results of the t-test show that there was a significant difference between the overall average academic grades of the traditional group and the experimental group. The test statistic of *t* was used in making the decision about the rejection of the null hypothesis. The P-value of 0.0406 can be interpreted as statistically significant as it fell between 0.01 to 0.05. The P-value is sufficient evidence against the null hypothesis. Refer to Table 2 and Figure 1.

Table 2

	Sample Size	Test Statistic, *t*	Critical *t*	P-value	Accept or Reject the null hypothesis
Control Group vs. Experimental Group	40	-2.1181	±2.023	0.0406	Reject

Figure 1



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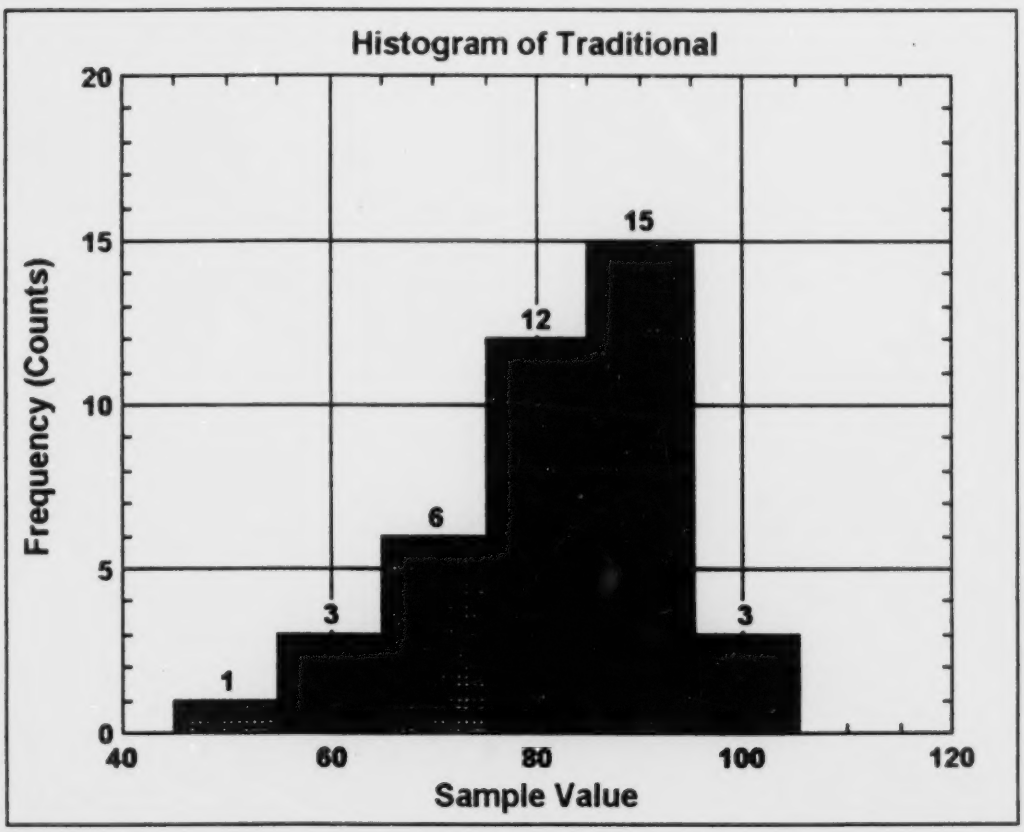
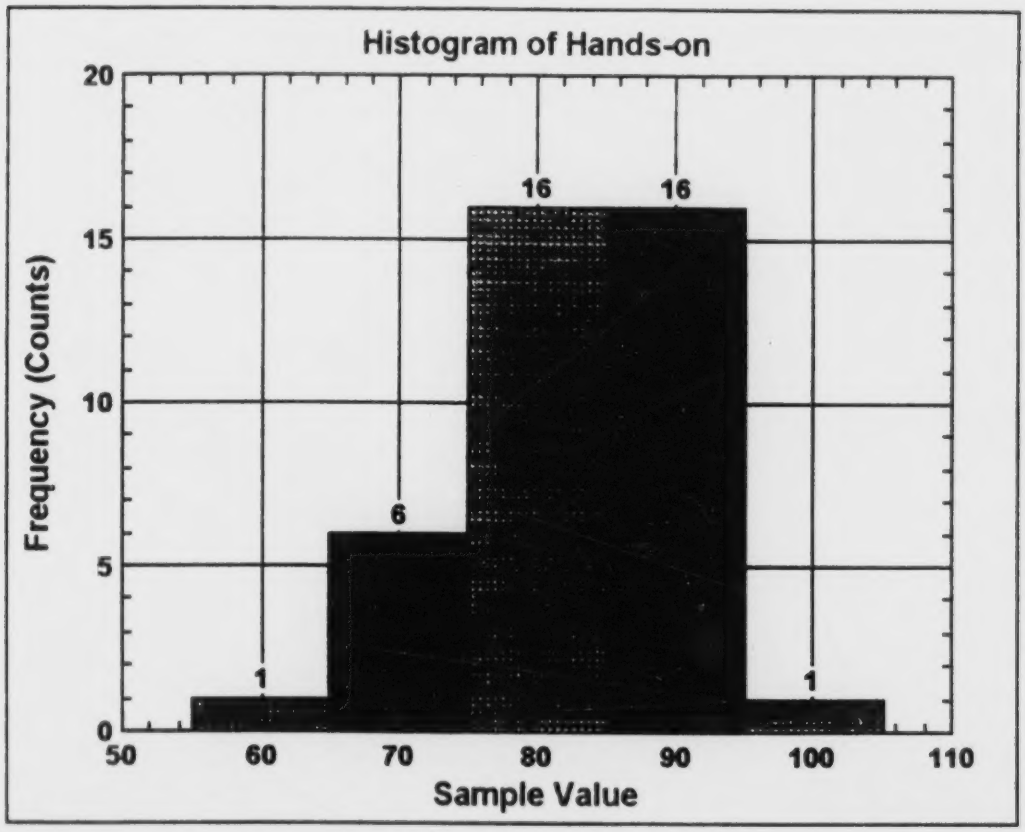
The histogram consists of a horizontal scale for percentage of academic grades, and a vertical scale for frequencies. Figure 2 represents the traditional academic grades and reveals a wide distribution of grades.

Figure 2



The histogram in Figure 3 represents hands-on academic grades and reveals a higher percentage of students falling in the 75% to 95% range.

Figure 3



Since the null hypothesis was rejected, the study can be referred to as being statistically significant. The finds of the study applies to the entire population with a 95% confidence interval.

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Chapter 5

Discussion

The purpose of this study was to determine if altering teaching methods would affect the academic grades of Science 9 students. The H_0 stated that students learning by traditional science instruction will have the same academic achievement as students who learn by hands-on science instruction. The H_1 stated that students learning by hands-on science will have higher academic achievement. The statistical evaluations by the t-test statistic for hypothesis testing rejected the null hypothesis. This concludes that academic achievement is higher for students taught by the hands-on method.

From the research discussed in chapter two, the findings are equivalent. Students can achieve higher academic performance using hands-on science. Also, students can excel in other areas afforded by hands-on learning such as getting along with other students, functioning independently, becoming less dependent, working interdependently, completing tasks on time, and utilizing various social skills.

All studies have some limitations, and this one is no exception. For example, academic grades were compared, but the various methods for acquiring grades or the types of items graded could affect outcomes. Grades can be collected from written, oral, or demonstration type work whether daily scores or tests. Also, the teacher may strictly adhere to the percentage grade or use a grading scale to enhance achievement. Therefore, all these variables should be constant for the teacher when doing research concerning the two teaching methods.

This research might change the opinions of teachers toward hands-on experimenting. The classes involved have gradually received more hands-on activities over the years and this trend will continue to increase. The various ways in which to accomplish hands-on instruction has expanded from this research. Science teachers need more access to basic, reliable experiments for science classes and also the funding necessary to carry this out. Too many times the teacher must locate experiments to supplement a textbook based curriculum. Adequate training is necessary for teachers to meet the changes in teaching, especially in the new technological world.

Further research should be completed in the area of methods of instruction and larger samples for longer periods of time would provide more accurate data. A broader range of teaching techniques and their effectiveness should also be researched. Teachers need to be able to share improvements, failures, and opinions in science teaching.

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Appendix A

Permission Form

Ritchie County High School
Ellenboro, W.V.

To whom it may concern,

The research as described in Chapter 3-Methods of the Thesis: A Comparison of Traditional Science Instruction to Hands-On Science Instruction submitted by Judith L. Butta to Salem-Teikyo University has been approved by the undersigned. (No student names will be used.)

John Ditlow, Principal

G.A. McClung, Superintendent

Appendix B

Textbook Tests

NAME _____ DATE _____ CLASS _____

CHAPTER TEST

Chapter 4

Electromagnetic Waves

I. Understanding Concepts

Match each item in Column I with the most appropriate item in Column II. Write the letter for that item in the blank to the left. Use each lettered term only once.

Column I	Column II
_____ 1. frequency	a. vibrates at right angles to direction the wave travels
_____ 2. diffraction	b. bending of light around corners
_____ 3. transverse wave	c. distance from one wave peak to next wave peak
_____ 4. wavelength	d. used in long-distance telephone calls
_____ 5. microwaves	e. number of waves that pass a point in one second

In the space provided, write the word or words that best complete(s) the sentence.

_____ 6. _____ interference occurs when waves cancel each other.

_____ 7. Radio waves and _____ are used for communications.

_____ 8. _____ are used to detect cavities.

_____ 9. _____ waves are the lowest frequency electromagnetic waves.

_____ 10. _____ waves are the shortest wavelength electromagnetic waves.

Complete the following item.

11. Number the waves in order of wavelength. List the longest wavelength as 1 and the shortest wavelength as 7.

_____ radio waves

_____ ultraviolet waves

_____ gamma rays

_____ microwaves

_____ light

_____ infrared radiation

_____ X rays

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NAME _____ DATE _____ CLASS _____

Chapter Test 4 (continued)

II. Applying Concepts

In the blank at the left, write the letter of the choice that best completes the statement or answers the question.

_____ **12.** If the frequency of a 10-m wave is doubled, the wavelength will be _____ .
a. 20 m **b.** 15 m **c.** 10 m **d.** 5 m

_____ **13.** Electromagnetic waves differ from water waves in that electromagnetic waves _____ .
a. require a medium to travel **c.** are longitudinal waves
b. can travel through a vacuum **d.** carry energy

_____ **14.** A soap bubble is an example of _____ .
a. light being reflected from a mirror **c.** diffraction of light from two surfaces
b. a thin film **d.** a thermoscope

_____ **15.** Diffraction of light is more obvious when _____ .
a. a soap bubble is viewed in ordinary light
b. the slit size is large
c. the slit size is small
d. a soap bubble is viewed through a color filter

_____ **16.** Electromagnetic waves transmit _____ .
a. charged particles **c.** energy
b. matter and energy **d.** electrons

_____ **17.** Diffraction and interference patterns demonstrate _____ .
a. that light can be reflected from different types of surfaces
b. that the speed of light is constant
c. the wave nature of light
d. that light travels in straight lines

_____ **18.** If two sets of waves with the same amplitude arrive at the same place so that the crest of one wave lines up with the trough of the other wave, there will be _____ .
a. constructive interference **c.** a wave with twice the amplitude
b. destructive interference **d.** a wave with half the amplitude

_____ **19.** What color of clothing would be the best choice for a trip to Jamaica?
a. white **b.** blue **c.** black **d.** yellow

_____ **20.** Which of the following waves have the shortest wavelengths?
a. UHF TV waves **c.** FM radio waves
b. VHF TV waves **d.** AM radio waves

_____ **21.** Red light spreads out more than blue light when passing through a slit because _____ .
a. red light has a shorter wavelength **c.** of constructive interference
b. blue light has a shorter wavelength **d.** of destructive interference

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NAME _____ DATE _____ CLASS _____

CHAPTER TEST

Chapter 6

The Periodic Table

I. Understanding Concepts

Match each item in Column I with the most appropriate item in Column II. Write the letter for that item in the blank to the left.

Column I	Column II
_____ 1. mass number	a. row on periodic table
_____ 2. isotopes	b. has properties of metals and nonmetals
_____ 3. alkali metal	c. sodium, potassium
_____ 4. metalloid	d. number of protons in nucleus
_____ 5. periodic table	e. atoms of an element with different numbers of neutrons
_____ 6. atomic number	f. column on periodic table
_____ 7. family	g. number of protons and neutrons in nucleus
_____ 8. period	h. elements arranged by increasing atomic number

Use the portion of the periodic table to answer the following questions. Write the answer in the space provided.

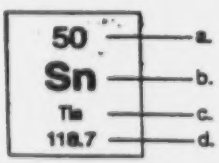
_____ 9. There are _____ electrons in the outer energy level of the silicon atom.

_____ 10. The elements Ge, As, and P are in _____ different periods.

13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3

Complete the following item.

11. Label the types of information given in the periodic table as shown in the figure.



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NAME _____ DATE _____ CLASS _____

Chapter Test 6 (continued)

II. Applying Concepts

In the blank at the left, write the letter of the choice that best completes the statement or answers the question.

_____ 12. Each row in the periodic table begins a _____ .
- a. new family
- b. repeating pattern of physical and chemical properties of elements
- c. new set of elements that share the same number of outer electrons
- d. new set of elements which have the same chemical properties

_____ 13. Elements in the periodic table are arranged by increasing number of _____ .
- a. neutrons
- b. protons
- c. protons and neutrons
- d. electrons in the outer energy level

_____ 14. Atoms of the same element always have the same _____ .
- a. number of neutrons
- b. atomic mass number
- c. atomic number
- d. mass number

_____ 15. A dot diagram consists of a symbol representing the element and an arrangement of dots which represents the _____ .
- a. number of electrons in the atom
- b. number of positrons in the atom
- c. electrons in the outer energy level of the atom
- d. atomic number

_____ 16. Family 1 metals are called _____ .
- a. alkaline earth metals
- b. alkali metals
- c. metalloids
- d. halogens

_____ 17. Which elements in the periodic table are most likely to react?
- a. alkaline earth metals
- b. alkali metals
- c. noble gases
- d. metalloids

_____ 18. Elements on either side of the stair-step line in the periodic table are called _____ .
- a. transition elements
- b. noble gases
- c. halogens
- d. metalloids

_____ 19. The alkaline earth metals _____ .
- a. have 3 electrons in their outer energy level
- b. have 2 electrons in their outer energy level
- c. do not have any isotopes
- d. belong to the actinide series

_____ 20. The alkaline earth metals are found in _____ .
- a. periods 2 through 7 only
- b. periods 4 though 7 only
- c. periods 4 though 6 only
- d. periods 1 though 7 only

_____ 21. What period of the periodic table contains only two elements?
- a. period 7
- b. period 2
- c. period 1
- d. period 8

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NAME _____ DATE _____ CLASS _____

CHAPTER TEST

Chapter 8

Molecules in Motion

I. Understanding Concepts

Match each item in Column I with the most appropriate item in Column II. Write the letter for that item in the blank to the left. Use each lettered item only once.

Column I	Column II
_____ 1. kinetic-molecular theory	a. For a fixed amount of gas at constant temperature, pressure and volume are inversely proportional.
_____ 2. thermal expansion	b. A solid becomes a liquid.
_____ 3. Boyle's law	c. lowest possible energy matter can have
_____ 4. Charles' law	d. For a fixed amount of gas at constant pressure, volume and temperature are directly proportional.
_____ 5. melting	e. liquid's resistance to changing shape
_____ 6. viscosity	f. expansion that occurs when a solid is heated
_____ 7. absolute zero	g. Atoms and molecules are in constant random motion.

In the space provided, write the word or phrase from the following list that best matches the statement given. Answers may be used more than once.

a. increases	b. decreases

_____ 8. If the gas in an oxygen tank is heated, the pressure does this.

_____ 9. If the air pressure is reduced in a tire, the temperature of that air does this.

_____ 10. If the container that holds helium gas is enlarged, the pressure of the gas does this.

Complete the following item.

11. Fill in the missing data in the table.

Law	Temperature	Pressure	Volume
a.	constant	b.	decreases
c.	d.	constant	increases

In the blank at the left, write the letter of the choice that best completes the statement or answers the question.

_____ 12. A liquid changes into a gas through _____.
a. condensation b. evaporation c. desalination d. sublimation

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NAME _____ DATE _____ CLASS _____

Chapter Test 8 (continued)

_____ 13. The collisions of a gas's molecules determines the gas's _____ .
a. temperature b. volume c. pressure d. solubility

_____ 14. The process of matter changing from a solid directly into a gas is called _____ .
a. evaporation b. sublimation c. expansion d. condensation

_____ 15. A change of matter from gaseous to liquid is called _____ .
a. condensation b. sublimation c. evaporation d. liquification

II. Applying Concepts

In the blank at the left, write the letter of the choice that best completes the statement or answers the question.

_____ 16. When thermal energy is added to a gas, the result is an increase in _____ .
a. molecules b. solids c. temperature d. viscosity

_____ 17. 37°C is equal to _____ .
a. 37 K b. 69 K c. –236K d. 310 K

_____ 18. Most liquids expand when they are _____ .
a. heated b. evaporated c. melted d. cooled

_____ 19. When energy is added to a solid, the molecules vibrate _____ .
a. the same amount c. faster
b. slower d. none of the above

Answer the following questions in one or two complete sentences.

20. How is sublimation different from evaporation? _____

_____

21. Why is a solid's molecular arrangement fixed? _____

_____

_____

22. Why does a solid expand when heated? _____

_____

_____

_____

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Appendix C

Teacher Tests

Metric Test

1. Draw the metric conversion line and label it in one of the basic metric units we have studied.

2. _____ = basic metric unit for length

3. 1 mm = _____ m

4. 1 dm = _____ m

5. 1 km = _____ hm

6. 2.5 m = _____ hm

7. 1 m = _____ km

8. _____ - basic metric unit for mass (weight)

9. _____ - basic metric unit for volume (capacity)

10. 2500 g = _____ kg

11. 4.2 kg = _____ g

12. 250 ml = _____ l

13. 1 ml = _____ l

14. 10 g = _____ dkg

15. 100 l = _____ ml

16. 24.8 mm = _____ m

17. .5 l = _____

18. 1750 g = _____ kg

19. Which of the following is closest to the length of our classroom?
    a) 12 m b) 6 m c) 10 m

20. What is the boiling point of H_2O (water)? _____ ^oC

21. Which of the following is closest to to the weight (mass) of a paper clip?
    a) 2 g b) .5 g c) 5 g

22. What is the freezing point of H_2O (water)? _____ ^oC

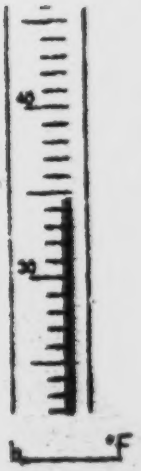
23. Which container had a curved H2O surface called a meniscus?
    a) flask b) beaker c) graduated cylinder

24. Which prefix represents a larger unit?
    a) milli- b) kilo- c)deci-

25. Name one occupation in which "metric" is definitely required?

    _____

26. Read to the nearest .1



27. Convert the following temperatures:
    1) Write down the formula that you choose
    2) Set up problem
    3) Show all work
    4) Answer
    5) Give unit

$^{O}C = 5/9\ (^{O}F-32)$ or $^{O}F = 9/5 \times {}^{O}C + 32$

a) $60^{O}C =$ _____ ^{O}F

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Science Test
Density

1. 1 cm^3 = _____ ml

2. What is the unit for mass? _____

3. What is the unit for volume? _____

4. What is the unit for density? _____

5. What is the formula for density? _____

6. _____ - is a characteristic property of a substance.

7. .0012 g/cm^3 is most likely the density for a solid, liquid, or a gas?
_____

8. 11.3 g/cm^3 is most likely the density for a solid, liquid, or gas?
_____

9. The bottom of a water curve in a graduated cylinder is called the -
_____

10. The mass per unit volume of a substance is called -
_____

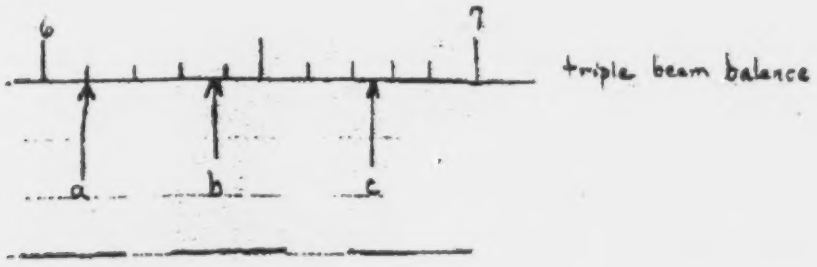
11. What formula would you use to find the volume of a rectangle?
_____

12. Underline the significant digits in the following numbers:
a) 125 b) 20.5 c) 0.72 d)5.00

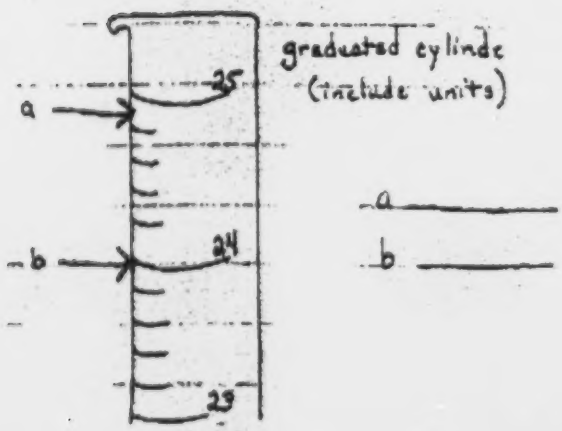
13. For division and multiplication, it is good to remember a simple rule of thumb: The result should have as many digits as the measured number with the -

---

14. Reading Scales - read the following positions (.01g .1cm^3) (include units)



15.



All Problems - Write formulas and show all work (give units and follow steps)

16. What is the volume of a block of wood whose measurements are 10.0 cm by .25 cm by 4.10 cm?

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17. What method is used to find the volume of an irregular object such as a rock? It is called - _____

18. A sample of alcohol amounting to .50 cm^3 has a mass of 0.41 g. What is its density?

19. A solid is placed in a test tube, and the mass of the tube and its contents is found to be 33.66 g. The tube is stoppered, and set up to collect gas. When heated a gas is given off, and its volume is found to be 470 cm3. After the reaction, the mass of the test tubeand its contents is found to be 33.16 g.

a) What is the mass of the gas collected?

b) What is the density of the gas collected?

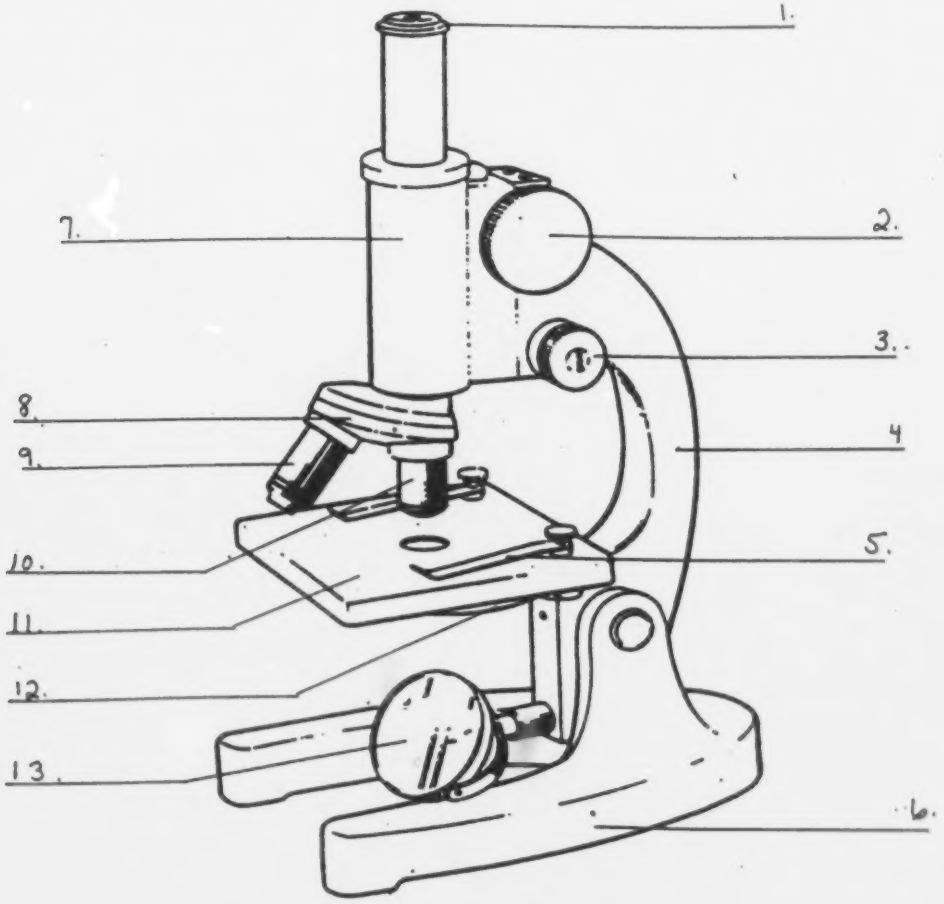
Microscope Test

Fill in the blanks:

1. _____ is used to focus the image under low power.
2. _____ regulates the amount of light entering the body tube.
3. Always carry a microscope upright with _____.
4. Never use the _____ to focus the high power objective.
5. _____ contains a magnifying lens that you look through.
6. _____ sharpens the image under high and low magnification..
7. Store the Microscope with the _____ objective in position.
8. Always bring a specimen into focus with the _____ first.
9. Clean lens only with - _____.
10. If the eyepiece magnifies 10X and the objective lens magnifies 43X, what is the total magnification? _____
11. When you change to high power, how does this change the area of the slide included in the high power field? _____
12. What happens to the specimen as you move the slide to the right (when viewed through the microscope)? _____

Analysis

Label the parts of the microscope in the drawing below.



Standard compound microscope